TRACING LIFE'S SECRETS

By G. H. SCHWABE

The search for the origin, nature, and meaning of life is as old as mankind. In this search, men have, for decades or even centuries, followed certain ideas. Then new points of view suddenly sprang up which to many at first seemed absurd but which foreshadowed new possibilities. It is in just such a period that we find ourselves today. We are going through a great political upheaval and can see how its influence has been extended even to the sciences. The very fact that entirely nonpolitical spheres are being drawn into this revaluation is a sign of the deep revolutionary significance of the present time.

The author's career is characteristic of the unorthodox approach to be found today in increasing measure in the world of science. Being a farmer's son, it had always been his desire to study that part of Nature which Man has left untouched. He was drawn to uninhabited regions where he could investigate life in its original state. To equip himself thoroughly for this task he studied chemistry, biology, physics, mathematics, psychology, geography, geophysics, and agricultural chemistry at the universities of Königsberg and Jena (Germany), Graz (Austria), and Reykjavik (Iceland). In the end he specialized in an entirely new subject, hydrobiology, the study of life in water—from the dewdrop to the ocean. In the hot springs, so intimately connected with the innermost secrets of the earth, he discovered an especially rich field of research that had hardly been explored. He has been working on this in Germany, Iceland, Chile, and, at present, in Japan, and has published the results of his studies in scientific periodicals of various countries.

In the following pages Dr. Schwabe deals with some of the new angles which he and his friends have discovered in their study of life. As is often the case with a new conception, it is likely to arouse opposition and in time to undergo certain modifications.—K.M.

In our world, so rich in differences and contrasts, one of the most trenchant distinctions separates that which has life from that which has none. We know that the Ionic philosophers knew no such distinction, since to them the cosmos itself appeared as a living whole. Even Aristotle and his followers in the European Middle Ages believed that living things were constantly being created from dead matter, and that in this way a bridge reached across the chasm which was becoming more and more apparent. However, when in the middle of the seventeenth century the English scientist Harvey pronounced the well-founded axiom: "*Omne vivum ex ovo*" (all life comes from the egg), and, as a result of Pasteur's discoveries some eighty years ago, this axiom was given its more universal form: "*Omne vivum ex vivo*" (all life comes from life), the imaginary bridges between the living and the lifeless world finally collapsed.

For the first time in history, Man now faces the riddles of life itself. All life comes from life. But what is life, with its independent laws that only apply to its own sphere? Where does it come from? Where does it lead? With such questions there suddenly arose, beside the multiplicity of forms of life which science had hitherto devoted itself to cataloguing, the great question of the history of life on earth and in the universe. Of course, scientists had formerly also run up against questions regarding the history of life, but this always happened in certain limited fields only. Not until the realization of "*omne vivum ex vivo*" was the revolutionary effect of Darwin's and Mendel's discoveries en-

sured. Now only, and with bitter disputes, did modern biological research begin, replacing existence with growth and fixed conditions with process.

THE LIMITS OF SCIENCE

The first convulsions, which characterize the last century's faltering conception of the world, have now given way to the purposeful advance of a science which refuses to attempt to solve scientifically insoluble riddles of the universe. The question of the origin of life definitely no longer concerns the field of biology. Instead, it is left to each individual to decide whether he wants to choose one of the four age-old, fundamental possibilities of solution, and if so, which. It is purely a matter of faith whether life is a divine creation, whether it arose from dead matter in the form of the most primitive cells through original procreation, whether the cosmos itself is really a living whole which has only excreted dead matter, or whether germ cells of life, eternally scattered throughout the universe, brought life to our planet during the course of the earth's history. In its sincere striving for knowledge, modern science must admit that for it each of the four attempts at solution is equally improbable because it is inaccessible. One might just as well ask how nickel or gravity came to be.

LAWS FOR THE LIVING AND THE LIFELESS

But we do know today that all inorganic chemical and physical laws apply to every living, organic being in the same way and without exception as they do to lifeless forces and matter. The body of a sea gull obeys the law of gravity just as much as does the cliff over which the gull is soaring. The iron in the golden crystals of pyrite has the same chemical reactions as the iron in human blood. The inorganic laws of Nature do not in any way grant life an exceptional position. However, all living things are bound by a structure of other laws, none of which has effect or can be traced in the sphere of lifeless matter. Only in this sense does life overcome the laws of Nature; it has freed itself from them by submitting to its own, equally severe laws. Hence the freedom of life is founded on the recognition of its own laws. The miracles of life of which we speak take place solely within the bonds of its own laws.

Our present knowledge of these laws of life is barely enough to allow us to sense, from its countless, manifold effects and from tiny fragments of a world still unexplored as a whole, that there is an almighty structure, a vast plan. If we use the word "plan" here for lack of a better expression, this is only to indicate that in the sphere of life there are far fewer coincidences than one would like to believe. Since their number is constantly on the decrease, the idea of a governing plan impresses itself upon us with growing force. But this does not mean that we can even attempt to grasp the origin, purpose, and goal of this "plan." The workings of a plan in the manifestations of life cannot be disputed; the "plan" itself, however, exceeds the limits of our conception, just as we cannot conceive light-years and atomic nuclei, the working quantities of modern physics.

In the same way that we can recognize a similar order in the largest and smallest units of physics—the planetary systems and the atomic structure—the life of a cell, when observed closely, becomes the image of human life or the life of a people and finally a symbol of life itself. It can actually be considered a distinguishing mark of life that every manifestation, every tiniest existence, can be regarded as an individual expression of the whole, as an image of life itself. Every instant is filled with millionfold procreation and millionfold death. Out of the ocean of lives, let us pick out one example, the life of some higher animal, and study it.

THE CELL

The unfertilized ovum is a minute sphere of protoplasm measuring a few thousandths of an inch in diameter. Its structure is more or less the same as that of any other cell. Exactly a cen-

tury has passed since the cell was discovered to be the basic component of all living bodies. It was even regarded as the simplest component. But what miracles of organization and production are to be found in this "simplest component"! There is a nucleus suspended, besides many other granules, in an inextricable tissue of semiliquid shreds of protoplasm, among which are embedded vacuoles and tiny drops of fat. In its manifold structure, hardly discernible even under the strongest microscope, its minute body contains the decisive potentialities for higher life. Of course, there are also innumerable species of creatures whose cells have no nucleus. The chief of these are the so-called primitive groups who cannot yet use the principle of sex for maintaining and developing their kind. A cell either with or without a nucleus can have its own existence, and in this sense it is definitely the simplest component of life. It can absorb nourishment, it can grow, move, respond to outside irritation in such a way as to act for its self-preservation, it can repulse many kinds of attack, and it can split up and multiply. All these abilities are marks of the most "primitive" form of life. How deep and unbridgeable appears the chasm which separates even this most primitive form of life from the realm of lifeless matter!

OVUM AND SPERM

What is the ovum like? It lies quietly waiting. We must employ the most intricate methods to observe its process of life, which is limited to a minimum. For wherever there is no circulation of matter and no movement, there can be no life. (Only below freezing point does this law perhaps not apply.) In spite of its apparent inactivity, the ovum is alive. The protoplasmic structure, characteristic of every cell, is enough to reveal that, if only for the maintenance of this structure, purposefully directed forces, in other words life, is necessary. The ovum waits and finally dies, like most other ova, if it is not fertilized.

Several hundred times smaller than the ovum are the extremely mobile sperm cells which are often excreted by the million. They are really only cell nuclei, equipped with very powerful means of propulsion, which swarm out into space, soon to perish there—all but one, the one which fertilizes the ovum. Millions of these miraculous creations issue forth in order that at least one of them may fulfill the law inherent in all of them. In such prodigalities is revealed the incomprehensible forcefulness of life, life which sacrifices countless individuals in order to attain the prescribed goal in a single one.

At the moment of fertilization, the mobile, seeking principle is united with the passive, waiting one. The fusion of the two nuclei takes place within the ovum, violently changing the entire appearance of the cell. Through this extremely complicated process, which nevertheless takes place according to strict rules, the ovum becomes a germ and thus potentially a living creature. In the germ, a form predestined in all its details suddenly forces its way towards realization. It can only fulfill its prescribed individual destiny—or die. Within the first few minutes after fertilization, the miracle of cellular division begins and with it the march toward individual existence. One cell systematically grows into hundreds, thousands, and finally billions; groups of cells systematically separate and form organs, tools of the whole; and, with impressive loyalty, the image of the forbears is systematically reborn in every tiny particular so as to obey throughout its whole existence the same law which governed those very forbears.

THE BLOOD OF THE ANCESTORS

The knowledge of such things must compel every thinking man to stand in profound awe of the creations of life: Like every single one of my fellow creatures, I too have grown from a tiny fertilized ovum. Everything I do and

think, the origins of all human activity, were once contained in it. At the same time, such knowledge unites Man with all creatures that follow the same laws. Yet the real content of this "simplest component" is even greater, it is as inexhaustible as life itself. In it is contained, not only the building plan of a shape and a destiny, but also the ability for eternal propagation. For this reason, those cells which, as the "most primitive organisms," are themselves individuals with individual destinies or which, as germ cells, contain the building plans for such individuals, are in truth immortal.

The germ, which now prepares for division, bears within itself the heritage of countless ancestors and thus the commands for equally countless descendants. Ten ancestral generations ago there were more than a thousand individuals and fourteen generations ago more than thirty thousand who shared in the heritage of this single germ. These forbears are irrevocable history. All that determined their lives, all that they realized in their children and thus placed in this one cell, all this becomes the immutable law of a new life. Thus every creature ever conceived is, through his forbears, deeply interwoven into the community of procreation of his tribe, his population, his people. And, on the other hand, each creature is capable in the same way of unfolding his heritage in constantly spreading ranks of coming generations. Currents of forces flowing from long-forgotten armies of ancestors to still unborn hosts of descendants are concentrated in every living thing which has sex. Even the greatest artist, the most learned scientist, the noblest hero, has inherited nothing, absolutely nothing, beyond that which was passed on to him at conception.

LIFE AND FREEDOM

Yet this heritage is infinitely greater and richer than anything a human being can attain even through supreme efforts throughout his entire lifetime. Among millions of sperm cells, only one achieves fertilization, and of the entire heritage contained in this cell only a fraction appears visibly in the growing individual. The son inherits infinitely more from his father than can be seen, and he passes it on to his descendants. It remains temporarily in impenetrable darkness and flows on into the future, squandering itself again in millions of variants. In this way the living creature carries out and passes on the orders of life, orders it does not know and against which it cannot revolt. And yet it goes through its existence freely and easily.

Up to present times mankind has given much deep thought to the idea of freedom. Much of this thought was wasted in wrong directions. Freedom is not an abstract conception which interests Man theoretically. What matters is the freedom of the individual in his concrete life. However, freedom of the individual is only possible within the gifts inherited by him, never in opposition to them. Seen biologically, the greatest freedom is to be found where the inherited attributes have been most strongly developed. If the individual's urge for freedom is not directed toward the fulfillment of that which he has inherited, he hinders his own development.

BEGINNING AND COMPLETION

The ova of the various species are exceedingly similar to each other, and sometimes they cannot be distinguished at all. And yet, from this simplest of all shapes, the sphere, every creature grows toward its own, individual shape. The germ has only this one possibility, or it must die. The sphere, the epitome of quiescence, and the sperm cell with its long, rapidly lashing flagellum, a symbol of movement, are perfect shapes that exist not only for the purposes of procreation but also as the perennial forms of thousands of single-cell animals and plants. The final result of this develop-

ment, the complete organism, also appears always as a perfect shape. Looking at the two basic forms at the beginning of life (the ovum and the sperm cell) and at the completed form that has finally developed to maturity, the various stages passed through by each individual in this development (embryo, larva, etc.) seem all the more imperfect the further they are removed from either of the two end stages. A four-months-old human embryo, for instance, is manifestly not an end in itself but a transitional phenomenon which is quickly left behind and changed. These stages must be systematically gone through in order to form that final shape which is the invisible goal of every ovum. Here again we see the bond which holds together the whole infinite multiplicity of procreative life: every living thing, even the most complicated, begins its existence with the most primitive basic forms of the germ cells. All the secrets of life are concentrated within the smallest possible space in these minute bodies.

IS NATURE PRACTICAL?

The mature form which is finally achieved appears to us as perfect, complete. However, it is a prejudice to think that it is also eminently practical, suited to its purpose. The vast multiplicity of the forms and processes of life is enough to prove that practicability cannot be the aim or even a secondary aim of life. Practicability would create as few norms as possible and would be obliged to cling to them. Practicability would eliminate all waste. But life knows no binding norms: it lets constantly new forms arise. It dissipates its strength, which is far too mighty to be able to serve practical ends. Those who examine creatures for their practicability are cleverer than life. They will finally have to admit that a living body possesses only that minimum of practicability which is indispensable for maintaining itself and its species. And that not even these limits are adhered to is proved by petrified examples of extinct prehistoric animals and plants. They died out, just as is still happening today, after life had had millions of years to gather experience, simply because they were not practicable.

It is said that the urge for self-preservation is one of the most practical means for maintaining the species. Quite aside from the fact that in innumerable cases the maintenance of the species is actually ensured through self-sacrifice—one need only think of the expressions of animal mother-love or of those plants which die off as soon as the act of propagation has been completed—it still remains very strange that one species should be maintained which threatens to destroy another equally useful species. From this it follows, of course, that animals and plants were not created for Man's purposes. No, usefulness or practicability are not fit criteria: life obeys other laws.

THE LABORATORY OF THE BODY

The path of a creature from the germ to the completed form, and its capacity for eternal propagation, seem to teach us that life must have at its disposal mysterious forces which are unknown to the inorganic world. All the more surprising is the knowledge that all processes of life are brought about solely through the application of chemical and physical laws. When a cell creates billions of its kind; when a migrant bird flies halfway around the globe every year; and when a forest rises from the seeds of a single tree—then all these for us incomprehensible things are brought about by inorganic forces which are well known to us. The innermost secret of life, which remains unfathomable, is not these forces but the plan behind them.

The immeasurable abilities of a living body are founded exclusively in the fact that it is able to order and exploit the existing forces and substances according to its own plan. In this, indeed, it

reveals an ingenious practicability in its behavior which never ceases to arouse our wonder. The same substances which share predominantly in the composition of the outer layers of our planet, such as hydrogen, oxygen, nitrogen, carbon, calcium, magnesium, and iron, also compose the organic substance, the bearer of life, in plants, animals and humans. Apart from a few exceptions, all of which can also be found only in traces in the inorganic world, all elements have been discovered in animal and vegetable bodies.

However, the living organism is by no means content with the available substances; without any pattern to go by, it invents and creates new, extremely complicated chemical bodies. It produces albumens, carbohydrates, and fats. In each of its countless cells, and at every instant, manifold, often contrary chemical changes take place. In the course of this, great energies are released at one place and are bound at others; but always the profit is greater than the loss. For the energies thus produced must serve for further replenishment, as well as for movement, the real manifestation of life.

It is clear that, in order to carry out all these processes according to plan, the individual parts of the organism down to the smallest members must be in constant communication with each other and exert reciprocal influence. The nervous system, the vascular bundles, the blood circulation, the organs of perception, are only a few of the most important lines of communication which ensure the unity, the entity, of the organism. But life masters not only substances but forces. Almost all the forms of energy we find in the inorganic world, such as warmth, light, electricity, and gravity, are everywhere made to serve life in the most varied ways.

THE CAUSE OF ALL MOVEMENT

To a primitive people, our technology may seem like black magic, like the manifestation of supernatural forces. And yet it is no more than a coarse, very imperfect reproduction of the achievements of life itself. Just as our engineering systematically takes hold of and

directs the forces of Nature, life itself directs inorganic forces and substances. Only this is done with a perfection that we can never attain. Technology feeds its processes from tiny fractions of the energy of which the earth disposes. Life, however, has boldly conquered the mightiest source of power known to us: the sun. Life stretches out toward the flood of light which reaches earth from the universe. It is the sun which—except for the tides, volcanic activity, and manifestations of the aging of the earth—causes all movement on our planet. It is toward this cause of almost all movement that life turns directly. In its leaves, the plant creates that incomparable green coloring matter which enables it to make the best possible use of light imaginable. The invention of this chemical body, chlorophyll, is so inconceivably decisive that it has not only conquered almost the entire plant world but also forms, by means of very minor changes (an atom of magnesium is replaced by an atom of iron), the red coloring matter of the blood.

THE LONE FORCE OF LIFE

Protoplasm, cell, exploitation of solar energy, chlorophyll, red coloring matter of the blood, sex—these are a few magic words of life, ingeniously simple principles which are the foundations of infinite multiplicity. Every force can be transformed into any other force: electricity into light, heat, movement, sound; heat into movement, etc. Transmutability is a characteristic of force. In this sense, the force of life stands apart from the other forces known to us. No force can be transformed into life, nor life into any other force. The living organism employs the forces around it in order to realize the goal of its species. (By "the goal of the species" we mean

that form which a living organism would achieve if no outside influences affected its development.)

Every species attempts to achieve the goal of its species. And in the same way in which every organism follows this plan, we must assume that there is also an encompassing plan behind all life with all its manifestations. But it is a plan which we cannot conceive, since the comprehension of it lies beyond the borders of science in the sphere of religion.

COMMUNITY

This is more or less how life appears to us in this world. Every germ strives to achieve the form prescribed for it, strives to fulfill its destiny. Environment offers the means for this task, and at the same time it opposes the task with thousands of obstacles. Every step must be fought for. Harmful substances, destructive forces, and living enemies threaten the creature unceasingly. With the first preparations for division on the part of the germ begins the struggle for existence which is a struggle for growth and which with unshakeable certainty is finally ended by the death of the individual. In the knowledge of the existence of this law, which decides creation, growth, and death, are anchored the deepest roots of all morality. To the ceaseless struggle for bare existence, for growth, for the achievement of the prescribed goal and the fulfillment of the destiny of the species, is finally added the highest task of all, the struggle for the perpetuation of the species, the real struggle against death. In order that life be immortal, the individual must be sacrificed.

In this way, all creatures are united in a single community of struggle and death. Sex is the principle which creates order among communities of the same species: it creates the couple, the family, the clan, the tribe, the people, the race, and finally the state. Sex also forms similar communities in the case of plants and animals. Geographical situation creates new, different orders which go beyond the limits of the species. The most varied species of the animal and plant worlds ally themselves with one another in order to overcome common difficulties and dangers by mutual aid. The highest perfection of such communities is to be found in what is known as the symbiosis: for example, ants that raise fungi for their own nourishment; other ants that "milk" plant lice and in return protect them; higher plants that employ bacteria to obtain nitrogen; or primitive creatures that house algae in their own single-cell bodies for the production of organic substances. Such communities could be used as models for the farm with its utilization of plants and animals.

A widespread belief holds that living things adapt themselves to their environment as well as to other organisms, that adaptation is everything, that it overcomes all difficulties and ensures a comfortable existence. This belief has its origin in fundamental errors or in poor observation. If there is such a thing as adaptation, its extent is extremely limited, for the goal and the destiny of the species are inevitable. If an organism "adapts" itself, this certainly does not happen for the purpose of a comfortable existence but because of its unquenchable will to live. Adaptation is a strategy in the struggle for existence, nothing more. Self-sacrifice and boundless waste may be just such weapons in this struggle.

WAVE AND SEA

Every creature has only the one duty to achieve the goal of its species. Everything else is subordinated to this duty. In obedience to it, all sacrifices are made, all obstacles attacked, millions of fellow creatures of the same or of other species destroyed, whole areas of the world changed, new areas opened up for the same or for other species, and battles fought ceaselessly. But that is not enough: the goal of the species is not a fixed point, it is not a place of rest in this confusion. The goal of every species is mutable to a certain extent. With this realization disappears the last ray of hope for the inquiring mind to be able

one day to understand the plan of life of at least one single species. Each individual is unique; it bears within itself the spark of the new, of that which has never yet been, of that which will never return. Not only every species but every individual is a unique masterpiece of perfection. But nowhere is there anything final. *Panta rhei*: everything flows.

In this surging sea of life the individual appears and sinks away again. It is as ephemeral as the wave. Each individual goes its own way, and none is like the other. The foaming wavecrests catching the light of the sinking sun over the darkness of the water are a good image of our consciousness as individuals. It is carried up and sinks down again into obscurity. Thousands of passing wavecrests—they are not the sea, but they are lights flashing up out of its darkness.

Everything of which we have spoken here, however, takes place only on the thin outer crust of a tiny planet. What is beyond this planetary sphere of life, no one can say. With his science, Man feels himself master of this sphere and, following the laws of his restless mind, he invades its vast machinery, shaping and reshaping. He creates and explores and ponders, but he does not know his own final destiny, his goal within the whole.

* * *

It has been proved often enough that modern biological research, whose attitude has been shown here in outline, can gather amazing knowledge about the manifestations of life. There can be no doubt that it has made and can still make irreplaceable contributions toward the solution of practical problems in agriculture, industry, and politics. Far deeper, however, is the effect of modern biological research, directly and indirectly, on the existence of Man himself and on his future; for, in the final analysis, every tangent of biological study leads back again to Man.

The spirit of the world, the great calm presence of the creator, comes not forth to the sorceries of opium and wine. The sublime vision comes to the pure and simple soul in a clean and chaste body.

Emerson